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Physico-Chemical Characteristics of Ground Water in and around the Gandhamardan Iron Ore Mining area, Keonjhar District, Odisha, India

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Abstract

Mining and associated activities have quantitative and qualitative impacts on the water regime in and around the mines. Due to presence of iron ore belt water pollution attracts the attention of all. In the present study the ground waters around the Gandhamardan mining areas have been tested, where the iron ore opencast mines are present. The water quality parameters, viz. pH, Seasonal variation of different parameters have been compared with the standard. From the results mean, standard deviation, correlation coefficient and principal component analysis among parameters have been studied. The results show that ground water collected from different six locations with minimum variation in pH value ranges from 5.4 to 6.6 suggest acidic nature. Other parameters were more or less within the permissible limits of WHO.

Keywords: Ground water, physicochemical parameters, WHO standard.

Introduction

Ground water is the water located beneath the earth's surface in soil pore spaces and in the fractures of rock formation. Ground water acts as a reservoir and also source of water for wells, springs, bore well and Tube wells. These water sources for drinking and other domestic purposes must be free from any contamination due to rapid growth of Mining Operation like top Soil removal, deforestation. Overburden dumping affects the quality and quantity of the soil and ground water. Industrial activity may generate a wide variety of waste products. So, people are forced to use ground water [1-4]. The present study aims at physicochemical analysis of water quality in the Gandhamardan Mining Area of Keonjhar district (Latitude- 21°30́N and Longitude- 85°30́E) figure-1, where more than 5000 people are working. In these areas the surface of the earth is covered by both iron ore with forest and red soil. It is the tribal belt of Keonjhar district and the tribal people are dependent on tube wells for drinking water. Generally they have no clear idea about the good water quality and hence it was very much essential to assess drinking water quality in these areas to overcome the pollution problems through remedial measures[5].

Material and Methods

To assess the groundwater (Tube well) quality of the Gandhamardan Mining Area, Six different study locations were chosen (table-1). From each location a particular tube well was chosen and sampling was done quarterly from the particular tube well on January, 2013, (Winter) May, 2013 (Summer) and September, 2013 (Rainy). Samples were collected in sampler bottles. The water samples were collected during day time between 10A.M. to 12A.M. After collection and under preservation the samples were analyzed in the laboratory[6-10]. Using these samples different physicochemical parameters such as pH, TDS, BOD, COD, Cl^-, Total iron, Turbidity, SO_4^{2-}, total hardness were studied as per the standard procedure[7] (table-2).

Table – 1
Ground water sampling locations

Sl. NO.	Location	Sample Cods	Coordinates	
			Latitude	Longitude
1.	Urumunda Village	GW1	21°39́ 53.5˝N	85°27́ 32.5˝N
2.	Tala Jagar	GW2	21°38́ 25.8˝N	85°28́ 17.3 ˝N
3.	Nuadihi Village	GW3	21°38 20.0˝N	85°31́ 66.7˝N
4.	Ichinda Village	GW4	21°38́ 51.9˝N	85°31́ 11.4˝N
5.	Laupada Village	GW5	21°40́ 23.7˝N	85°30́ 7.0˝N
6.	Urumunda Village Talasahi	GW6	21°39́ 58.1˝N	85°27́ 30.4˝N

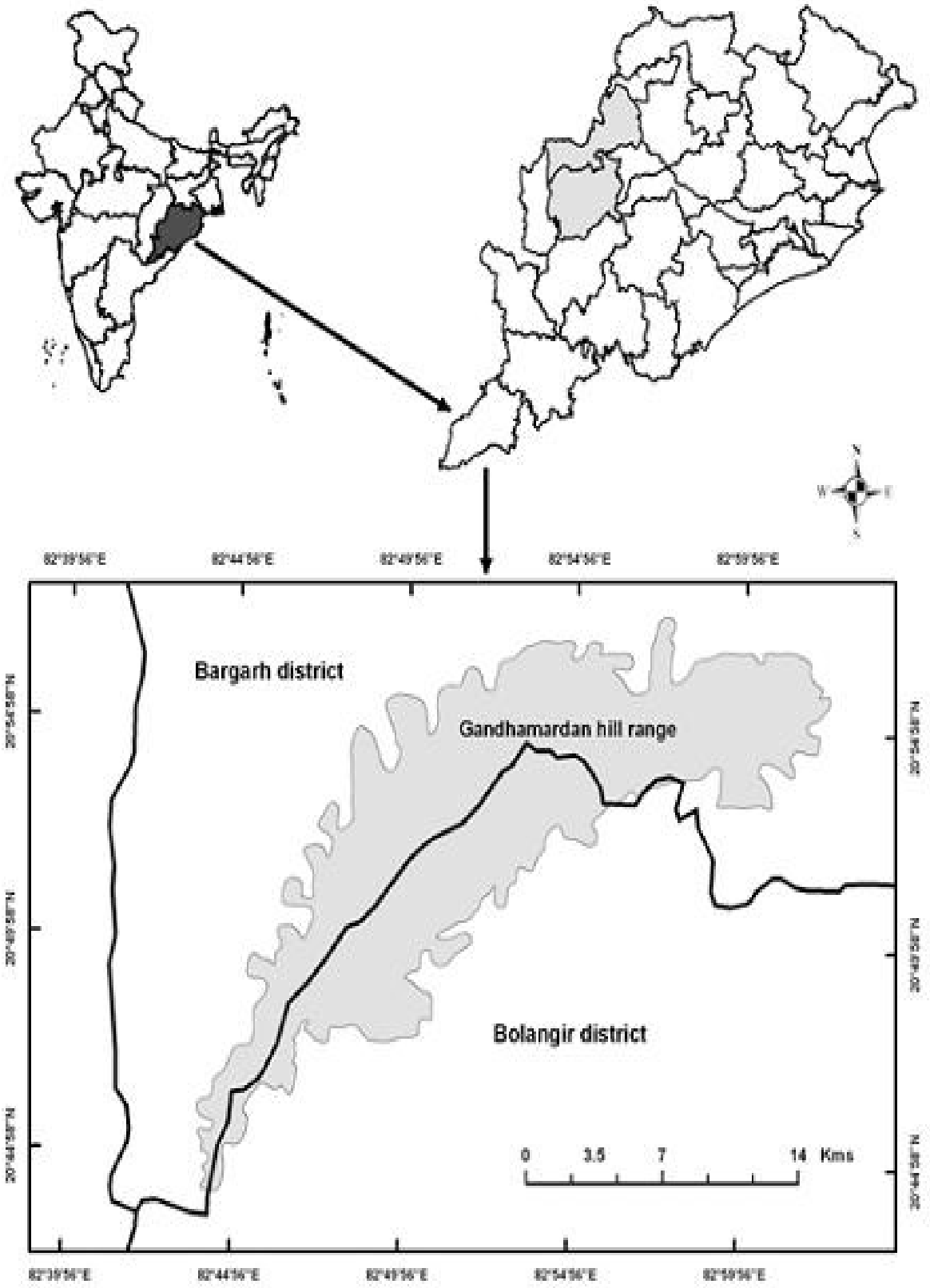

Figure-1
Map of Study Areas

Table-2
Methods of analysis of different Parameters

Parameter	Methods of analysis
pH	pH meter
TDS	Gravimetric Method
BOD	5day BOD test by incubation
COD	Open reflux method
T. Fe	1,10 Phenanthroline colorimetric method
Turbidity	Turbidometric method
SO_4^{2-}	Nephlo turbidity method
TH	Titrometric Method using EDTA

Results and Discussion

The results of different parameters were compared individually by taking 3 seasonal data and the results were reflected in (tables 4-12). The mean, standard deviation and correlation coefficient were shown in table- 13 and 14, respectively. The desirable limit and permissible limit of different parameters are given in table-3[9,10].

Table-3
Total characteristics for Drinking Water (Is10, 500, 1991) in mg/L

Substance Characteristic	Requirement Desirable limit	Permissible limit in absence of alternate source
pH Value	6.5 to 8.5	No relaxation
TDS Value	500	2,000
BOD	2.0	2.0
COD	20	20
Chloride (Cl^-)	250	1000
T.Fe (Iron)	0.3	1.0
Turbidity, NTU	5	10
Sulphate (SO_4^{2-})	200	400
Total hardness	300	600

Table-4
The pH value at different locations of Gandhamardan Mining Area, Keonjhar

Point	Jan	May	Sept
GW1	5.6	55	5.4
GW2	6.0	6.1	6.2
GW3	6.2	6.0	6.1
GW4	6.0	5.9	5.8
GW5	6.5	6.6	6.4
GW6	6.3	6.3	6.0

Table-5
TDS Value at different locations of Gandhamardan Mining Areas, Keonjhar in mg/L

Point	Jan	May	Sept
GW1	102	107	100
GW2	104	110	110
GW3	108	110	124
GW4	95	110	110
GW5	98	100	110
GW6	118	116	114

Table-6
BOD Value at different locations of Gandhamardan Mining Areas, Keonjhar in mg/L

Point	Jan	May	Sept
GW1	0.3	0.4	0.2
GW2	0.6	0.6	0.6
GW3	0.4	0.6	0.5
GW4	0.3	0.4	0.2
GW5	0.3	0.3	0.2
GW6	0.2	0.5	0.8

Table-7
COD Value at different locations of Gandhamardan Mining Areas, Keonjhar in mg/L

Point	Jan	May	Sept
GW1	1.6	1.8	1.1
GW2	2.0	2.0	2.0
GW3	2.1	2.1	2.1
GW4	3.0	3.0	3.0
GW5	2.0	2.0	2.0
GW6	3.0	3.0	3.0

Table-8
Chloride Content at different locations of Gandhamardan Mining Area, Keonjhar, in mg/l

Point	Jan	May	Sept
GW1	1.9	1.5	1.4
GW2	1.6	1.5	1.4
GW3	1.6	1.7	1.5
GW4	1.6	1.6	1.6
GW5	1.9	1.8	1.7
GW6	2.5	2.5	2.5

Table-9
Total Iron content at different locations of Gandhamardan, Mining Area, Keonjhar in mg/L

Point	Jan	May	Sept
GW1	0.16	0.16	0.16
GW2	0.22	0.23	0.24
GW3	0.23	0.24	0.25
GW4	0.20	0.20	0.20
GW5	0.11	0.15	0.16
GW6	0.10	0.11	0.12

Table-10
Turbidity content at different locations of Gandhamardan Mining Area Keonjhar, in NTU

Point	Jan	May	Sept
GW1	3.0	2.0	1.0
GW2	1.0	2.0	3.0
GW3	2.0	21.0	2.0
GW4	1.0	2.0	2.0
GW5	3.0	3.0	3.0
GW6	4.0	4.0	4.0

Table-11
Sulphate Content at different locations of Gandhamardan Mining Area, Keonjhar, in mg/L

Point	Jan	May	Sept
GW1	2.6	2.8	2.4
GW2	2.5	2.6	2.4
GW3	2.6	2.6	2.6
GW4	2.7	2.8	2.9
GW5	4.6	4.8	4.6
GW6	3.7	3.8	3.9

Table-12
Total hardness content at different locations of Gandhamardan, Mining Area, Keonjhar, in mg/L

Point	Jan	May	Sept
GW1	60	62	66
GW2	68	66	70
GW3	61	65	60
GW4	66	64	60
GW5	70	68	66
GW6	83	80	80

pH: The pH is used to express the acidity or alkalinity of a solution. The pH value of GW1 5.4 was minimum in the month of September and maximum in GW5 in summer 6.6. It was found in all the locations. pH value range from 5.4 to 6.6 suggest acidic nature of the ground water. The permissible limit is 6.5 to 8.5.

TDS: Total dissolved solids indicate the salinity behavior of ground water. According to WHO, the TDS value of ground water should be 500mg/L. TDS values in all the locations in all the seasons meet quality standards.

BOD: BOD value is maximum at GW2 in Jan (Winter) May (Summer), September (Rainy) than other five locations which were having within permissible limit (2.0mg/L).

COD: COD is used as a measurement of pollutants in waste water and natural water. COD value of all locations was found within the permissible limit (20mg/L).

Chloride: Chloride occurs naturally in all types of water. Chloride in natural water results from agricultural activities, industries, chloride rich rocks. In the study areas chloride level is within the permissible limit of WHO (250mg/L). The ranges of chloride were found 1.5 to 2.5 mg/L indicates less contamination of chloride.

Iron: The main sources of Iron in ground water are naturally as a mineral from sediment and rocks or from mining, industrial waste. The ranges of Iron found in all the locations in between 0.10 to 0.25mg/L. In comparison to others maximum amount of Iron content was found at GW3 in all the 3 seasons that was from 0.23 to 0.25mg/L. All the locations concentration was within the permissible limit. of water quality standard values that is 0.3mg/L.

Turbidity: Turbidity is due to colloidal and extremely fine dispersions. The turbidity range was found between 1.0 to 4.00 NTU. Minimum turbidity was found at GW2 and GW4 in the month of January. The turbidity limit according to WHO is 5NTU. All the locations were within the limit.

Sulphate: The sulphate values of water samples were found in between 2.6 to 4.8mg/L. In comparison to others GW5 samples were found sulphate content 4.6 to 4. 8mg/L in all the seasons. The ranges of sulphate content in all the location were below the permissible limit i.e. 200-400mg/L.

Total Hardness: Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of water. Hardness of water mainly depends upon the amount of calcium and magnesium salts. The hardness values shown range from 60 to 83mg/L, below the permissible limit 300mg/L.

Table-13
Average result of the physcio-chemical parameters in mg/L

Parameters	GW1	GW2	GW3	GW4	GW5	GW6	WHO 1973	ISI10500-91
P^H Value	5.5	6.1	6.1	5.9	6.5	6.3	7.85	6.5-8.5
TDS Value	103	108	114	105	103	116	1000	500
BOD	0.3	0.6	0.5	0.3	0.3	0.5	2.0	2.0
COD	1.5	2.0	2.1	3.0	2.0	3.0	2.0	2.0
Chloride (Cl^-)	1.6	1.5	1.6	1.6	1.8	2.5	250	250
T. Fe(Iron)	0.16	0.23	0.24	0.20	0.14	0.11	0.3	0.3
Turbidity,NTU	3.0	3.0	2.0	2.0	3.0	4.0	5.0	10
Sulphate (SO_4^{2-})	2.6	2.5	2.6	2.8	14.7	3.8	250	400
Total hardness	62.66	68	62	63.3	68	81	500	300

Statistical Analysis: Mean and standard deviation: After thorough analysis throughout the year 2013 given in table-14, maximum deviation from mean value was found in total dissolved solids and total hardness (5.41 and 12.43 respectively). Very slight deviation was found in pH, BOD, COD, Chloride, and Iron Content. Slight deviation was found in pH, turbidity and sulphate contents.

Correlation coefficient and Principal component analysis: Principal component analysis (PCA) was carried out and the results along with the eigen values and percentage of variance is presented in table- 15. The four factors accounted for 93.91% of total variance, which was sufficient to describe the data structure and had Eigen values larger than one and retained for rotation. The PC1 accounted for 34.44 %, PC2 accounted for 23.29 %, whereas PC3 and PC4 accounted for 22.32 and 13.85%, respectively. To assist interpretation of dimensions, the factor pattern was rotated using varimax method. Based on the guidelines provided by Stevens (1992), an attribute was considered to load heavily on a given component if the factor loading was >0.72. A total of nine attributes loaded heavily on four dimensions, while the loading of pH did not meet Stevens guidelines (<0.72). Three variables, i.e. TDS (-ve), Chloride (+ve), Total Hardness (+ve) were loaded heavily on PC 1, indicating strong correlations among these attributes. Further interpretation reveals that the factor loadings of Iron (-ve), sulphate (+ve) were loaded on PC 2, BOD (+ve), Turbidity (+ve) were loaded on PC3 and alone COD (+ve) were loaded on PC4 (figure-2 and 3).

The correlation coefficient (r) has a value between +1 and -1. The correlation between the parameters is characterized as strong, when it is in the range of +0.5 to 0.8 and -0.5 to 0.8, weak it is in the range of +0.0 to 0.5 and -0.0 to -0.5. The correlation analysis among different parameters is shown in table -16. The important correlations were between TDS-Chlorine content (-0.912), Turbidity-BOD (0.701), Total Hardness- TDS (-0.827), etc. Total dissolved solid content was negatively correlated with chlorine content of the ground water. Rest of the parameters has shown no intra-correlation such as sulphate, BOD, COD and iron.

Conclusion

From the analysis report it was observed that ground water quality at all the six locations were lower than the permissible limits of WHO standard. The level of these low concentrations of these ions does not have any considered impacts for this water to use for drinking and cooking purpose.

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Table-14
Arithmetic mean and standard deviation

Parameter	Mean	Std. deviation
pH	6.07	0.63
TDS	108.16	5.141
BOD	0.42	0.12
COD	2.27	0.30
Chloride (Cl^-)	1.73	0.116
T. Fe(Iron)	0.18	0.05
Turbidity, NTU	2.5	2.41
Sulphate (SO_4^{2-})	2.53	0.89
Total hardness	56.15	12.43

Table -15
Principal Component Analysis

	Component			
	1	**2**	**3**	**4**
pH	-.499	.583	-.228	.566
TDS	-.931	-.050	.199	-.037
BOD	-.295	-.134	.862	.154
COD	.013	-.320	.169	.901
Chloride	.955	.098	-.180	-.096
Iron	-.133	-.854	.344	.234
Turbidity	.116	-.009	.956	-.011
sulphate	.231	.925	.164	-.132
Totalhardness	.948	.195	.234	-.081

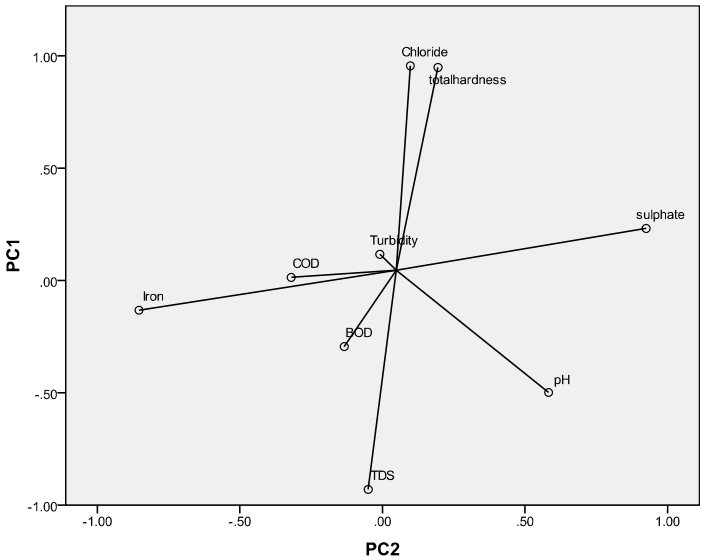

Figure- 1
Graphical representation of Principal Component Analysis (PC1-PC2) of different parameters analyzed for ground water quality around Ghandhamardhan area of Keonjhar

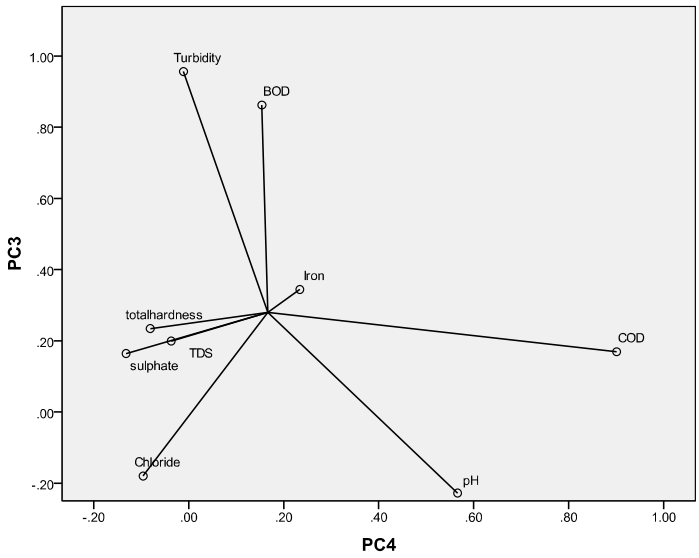

Figure-2
Graphical representation of Principal Component Analysis (PC3-PC4) of different parameters analysed for ground water quality around Ghandhamardhan area of Keonjhar

Table -16
Correlation analysis among different parameters

TD	BO	CO	Chlorid	Iron	Turbidit	Sulphat	Total
1	0.37	0.06	-0.912**	0.15	0.136	-0.249	-0.827**
	1	0.24	-0.429	0.55	0.701*	-0.062	-0.130
		1	-0.146	0.49	.209	-0.393	-0.072
			1	-	-0.080	0.276	0.893**
				1	0.253	-0.750*	-0.246
					1	0.148	0.344
						1	0.440
							1

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